



## Short Communication

# Coarse corn particles cause a negative effect on eggshell quality of semi-heavy laying hens



Vanessa R.M. Oliveira<sup>a</sup>, Alex M.V. Arruda<sup>a</sup>, Aurora S. Melo<sup>a</sup>, Davyd H. Souza<sup>b</sup>, João B.F. Souza-Junior<sup>a,\*</sup>, Raimunda T.V. Fernandes<sup>a</sup>, João P.A.F. Queiroz<sup>a</sup>

<sup>a</sup> Department of Animal Sciences, Universidade Federal Rural do Semi-Árido, Mossoró 59625900, Brazil

<sup>b</sup> Department of Animal Science, Federal University of Ceara, Fortaleza, CEP 60455-760, Brazil

## ARTICLE INFO

## Article history:

Received 22 December 2018

Accepted 18 March 2019

Available online 11 April 2019

## Keywords:

Egg quality

Geometric mean diameter

Productive performance

Poultry nutrition

## ABSTRACT

One of the possible ways to optimize the productive performance of poultry is through the physical processing of ingredients, which can improve the use of nutrients in these animals. In this context, this study was to evaluate the effects of different corn particle sizes in diets on the productive performance and egg quality of semi-heavy laying hens. Sixty naked neck laying hens were used from 24 weeks of age and distributed in a completely randomized design. Experimental diets in different treatments contained corn grain ground into sieves with a diameter of 2, 4, or 8 mm to provide corn particles with a geometric mean diameter (GMD) of 605 (fine), 1,030 (medium), and 2,280  $\mu\text{m}$  (coarse), respectively. The feed and leftovers were weighed daily throughout the experimental period to determine the feed intake and feed conversion. Different corn particle sizes did not affect any aspect of the productive performance of hens, except for feed intake. Hens fed fine and medium corn particles exhibited higher values for egg yolk color, eggshell weight, and eggshell thickness. It is suggested that semi-heavy laying hens should be fed mash diets containing corn particles with GMD from 605 to 1,030  $\mu\text{m}$ , because coarse corn particles cause a negative effect on eggshell quality.

© 2019, Chinese Association of Animal Science and Veterinary Medicine. Production and hosting by Elsevier B.V. on behalf of KeAi Communications Co., Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

One of the main causes of low productive performance of animals of economic interest is the thermal stress condition (Mascarenhas et al., 2018), characterized mainly by the high temperature in the breeding systems (El-Sabrouh 2018). In this sense, one of the possible ways to optimize the productive performance of poultry is through the physical processing of ingredients, which can improve the use of nutrients in these animals (Attia et al., 2012). In this sense, the particle sizes of the ingredients are given by the geometric mean diameter (GMD), which characterizes the mean sizes of particles, expressed in micrometers (Zanotto and Bellaver, 1996).

In recent years, the interest is increasing in the effects of dietary granulometry on poultry production, where studies continue to seek new practices to optimize the performance and feed efficiency of these animals (Frikha et al., 2009; Safaa et al., 2009; Attia et al., 2014a, 2014b).

However, studies on the effects of different particle sizes of diet ingredients on egg quality and productive performance show contradictory results. The lack of uniformity in these results may be associated with factors such as physicochemical characteristics of the ingredients, management, age and health status of the birds. (Frikha et al., 2011; Herreira et al., 2017). Safaa et al. (2009) observed that feed intake was higher in hens fed coarse wheat particles than in hens fed medium-sized and fine particles. However, Gewehr et al. (2010) observed that different corn particle sizes did not significantly influence the performance or egg quality of semi-heavy laying hens.

The use of appropriate particle sizes in feed formulations is of fundamental importance to improve performance and reduce production costs (Attia et al., 2014a, 2014b). However, little is known about the use of appropriate particle sizes to optimize egg production (Gewehr et al., 2011). The aim of this study was to

\* Corresponding author.

E-mail address: [souza.jr@ufersa.edu.br](mailto:souza.jr@ufersa.edu.br) (J.B.F. Souza-Junior).

Peer review under responsibility of Chinese Association of Animal Science and Veterinary Medicine.



Production and Hosting by Elsevier on behalf of KeAi

evaluate the effect of different corn particle sizes in diets on the productive performance and egg quality of semi-heavy laying hens.

## 2. Materials and methods

Animal care and handling procedures followed the guidelines of the Ethics Committee on the Use of Animals in Experiments of Universidade Federal Rural do Semi-Árido (CEUA-UFERSA).

### 2.1. Experimental location

The experiment was conducted in the poultry sector of the Federal Rural University of the Semi-Arid, Mossoró, RN, Brazil (latitude, 05 ° 11' S; longitude, 37 ° 22' W; altitude, 16 m above sea level). Environmental variables were measured during the trial period (Table 1). The wind speed (m/s) and air temperature (°C) was measured with a precision anemometer (Lutron, YK-2005AH, Kolkata, India). Relative humidity (%) were measured using a digital thermohygrometer (REED Instruments, 8726, Quebec, Canada).

### 2.2. Diets and experimental design

In total, 60 semi-heavy laying hens (Label Rouge line) at 24 weeks of age were selected and distributed in individual galvanized wire cages (length, 0.50 m × width, 0.45 m × height, 0.40 m) with feeders and nipple drinkers for 10 weeks. The hens were selected based on uniformity in body weight and laying rate, and then, were assigned to the various treatments in a completely randomized design. No artificial lighting program or climatization systems were used throughout the experimental period. The ventilation, air temperature and humidity inside the shed were controlled by the opening (07:00) and closing (17:00) of lateral curtains.

The hens were housed from the 24th to 34th weeks of age. The average weights of the hens at the beginning and end of the experiment were 4,150 and 3,980 g, respectively. The treatment groups were fed diets containing corn particles of different sizes. The corn was processed in a hammer mill with sieves, and the sieves are with diameters of 2, 4, and 8 mm. The GMD of the grain particles were measured with a granulometer as described by Zanotto and Bellaver (1996). The corn particles fed to hens had a GMD of 605 (fine), 1,030 (medium), or 2,280 μm (coarse).

Isonutritive diets were formulated according to Rostagno et al. (2011) for the nutritional requirements of semi-heavy laying hens based on the medium production of egg mass (Table 2), with feed (140 g/bird) supplied twice per day at 07:00 and 16:00, and water provided *ad libitum*.

### 2.3. Performance and qualitative analysis of eggs

Diets and leftovers were weighed daily throughout the trial period to determine the feed intake (g/bird per day) and feed conversion (the ratio of feed intake to egg mass, g/g). During the trial period, egg production was recorded daily to determine the laying rate (%), egg weight (g), and egg mass (g/bird per day). All eggs produced on 3 consecutive days each week were individually weighed and examined to assess their quality. The egg quality analysis was based on yolk weight (g), albumen weight (g), shell weight (g), shell thickness (mm), and yolk color.

**Table 1**  
Environmental conditions during the trial period.

| Environmental variable | Mean        | Minimum | Maximum |
|------------------------|-------------|---------|---------|
| Air temperature, °C    | 27.4 ± 0.05 | 24.0    | 31.0    |
| Relative humidity, %   | 82.2 ± 0.22 | 67.7    | 95.0    |
| Wind speed, m/s        | 0.05 ± 0.04 | 0       | 0.90    |

**Table 2**  
Ingredients and nutritional composition of feed for semi-heavy laying hens (%).

| Item                                   | Content |
|--|---------|
| <b>Ingredients</b>                     |         |
| Corn                                   | 62.00   |
| Soybean meal                           | 27.00   |
| Limestone                              | 8.00    |
| Dicalcium                              | 2.00    |
| Salt                                   | 0.40    |
| Vitamin supplement <sup>1</sup>        | 0.30    |
| Mineral supplement <sup>2</sup>        | 0.30    |
| <b>Nutrient levels</b>                 |         |
| Dry matter                             | 87.90   |
| Calcium                                | 3.65    |
| Available phosphorus                   | 0.67    |
| Ethereal extract                       | 2.69    |
| Neutral detergent fiber                | 11.30   |
| Acid detergent fiber                   | 4.39    |
| Crude protein                          | 17.40   |
| Apparent metabolizable energy, kcal/kg | 2,674.0 |

<sup>1</sup> Assurance levels per kilogram of product: vitamin A 10,000,000 IU, vitamin D 2,000,000 IU, vitamin E 30,000 IU, vitamin K 3.0 g, thiamine 2.0 g, riboflavin 2.0 g, pyridoxine 6.0 g, cobalamin 1.5 g, pantothenic acid 12 g, folic acid 1.0 g, biotin 1.0 g, niacin 50 g.

<sup>2</sup> Assurance levels per kilogram of product: copper 20 g, iron 100 g, selenium 0.25 g, iodine 2.0 g, manganese 160 g, zinc 100 g.

The eggshells were carefully washed to preserve their inner membranes and were then transferred to a forced air circulation oven to dry for 24 h at 55 °C. Then, the eggshells were weighed (g), yielding the percentage of the eggshell weight relative to the egg weight. The average eggshell thickness (mm) was determined by measuring the thickness at 3 points along the equatorial region of the egg using a digital caliper. The egg yolk color was visually analyzed using the Roche Yolk Color Fan (DSM Nutrition Product, Basel, Switzerland), with a scale of shades ranging from 1 (lightest) to 15 (darkest), as described by Stadlerman (1977).

### 2.4. Statistical analyses

An one-way ANOVA was performed to evaluate the effect of treatment groups on the parameters studied using SAS software (SAS, 1999). The averages were estimated by the least squares method and compared with Tukey's test ( $P < 0.05$ ).

## 3. Results and discussion

The effects of different corn particle sizes on the laying rate, egg weight, egg number, egg mass, feed intake, and feed conversion during the experimental period are shown in Table 3. There was no significant effect of corn particle size on the laying rate, egg weight, egg number, egg mass, or feed conversion. These results corroborate the findings of Safaa et al. (2009), who reported that feed particle size did not have a significant effect on egg production characteristics.

Feed intake was higher for hens fed coarse corn particles than for those fed fine corn particles ( $P < 0.05$ ). This higher feed intake with coarse corn particles, as well as the statistical similarity with hens fed medium corn particles, is attributed to the natural behavior of the birds in selecting coarse particles in the feed (Safaa et al., 2009; Attia et al., 2012). According Nir et al. (1994), coarse particles are better adapted to beak size than finely ground particles. However, even with the reduction in feed intake there was no reduction in productive performance for hens fed fine particles (Zhang and Coon, 1997; Fronte et al., 2013).

The effect of different corn particle sizes on egg quality are shown in Table 4. Herreira et al. (2017) and Hafeez et al. (2016) did not observe effect of different corn particle sizes on the yolk color.

**Table 3**  
Productive performance of semi-heavy laying hens fed corn with different particle sizes.

| Item                 | Corn particle size  |                      |                     | SEM  | P-value |
|----------------------|---------------------|----------------------|---------------------|------|---------|
|                      | Fine                | Medium               | Coarse              |      |         |
| Laying rate, %       | 64.42               | 66.33                | 67.86               | 0.34 | 0.30    |
| Egg weight, g        | 56.67               | 56.91                | 56.33               | 0.09 | 0.59    |
| Egg number           | 38.65               | 39.70                | 40.80               | 0.47 | 0.29    |
| Egg mass, g/hen      | 31.28               | 32.28                | 32.80               | 0.17 | 0.36    |
| Feed intake, g/hen   | 117.05 <sup>b</sup> | 118.24 <sup>ab</sup> | 122.03 <sup>a</sup> | 0.36 | 0.01    |
| Feed conversion, g/g | 3.75                | 3.67                 | 3.74                | 0.01 | 0.49    |

<sup>a, b</sup> With in a row, means with different letters indicate a significant difference (Tukey's test,  $P < 0.05$ ).

**Table 4**  
Egg quality of semi-heavy laying hens fed different corn particle sizes.

| Item                | Corn particle size  |                    |                    | SEM   | P-value |
|---------------------|---------------------|--------------------|--------------------|-------|---------|
|                     | Fine                | Medium             | Coarse             |       |         |
| Yolk color          | 6.70 <sup>a</sup>   | 6.40 <sup>ab</sup> | 6.30 <sup>b</sup>  | 0.03  | 0.03    |
| Yolk weight, g      | 14.32               | 14.46              | 14.09              | 0.03  | 0.13    |
| Yolk, %             | 25.22               | 25.37              | 24.97              | 0.05  | 0.31    |
| Albumen weight, g   | 36.99               | 37.01              | 36.99              | 0.07  | 0.99    |
| Albumen, %          | 65.31               | 65.04              | 65.68              | 0.06  | 0.15    |
| Shell weight, g     | 5.35 <sup>ab</sup>  | 5.43 <sup>a</sup>  | 5.24 <sup>b</sup>  | 0.01  | 0.02    |
| Shell, %            | 9.46                | 9.58               | 9.35               | 0.02  | 0.18    |
| Shell thickness, mm | 0.367 <sup>ab</sup> | 0.370 <sup>a</sup> | 0.362 <sup>b</sup> | 0.001 | 0.01    |

<sup>a, b</sup> With in a row, means with different letters indicate indicate a significant difference (Tukey's test,  $P < 0.05$ ).

In the present, yolk pigmentation was higher in the fine corn particles, while it was lower for hens fed coarse particles. The results of hens fed medium particles were statistically similar to those of hens fed the other diets. The smaller corn particle size possibly increased surface contact with intestinal enzymes and carriers, which favored enterohepatic absorption of carotenoids for ovary and egg yolk pigmentation, thereby enabling more efficient zeaxanthin absorption.

Eggshell quality (weight and thickness) was significantly affected ( $P < 0.05$ ) by corn particle size. The highest values were found in the medium corn particle size, which differed from the coarse, but both did not differ from the fine. Medium corn particles size allows a slow passage of food through the digestive tract, thereby improving the physical activity in the gizzard and intestinal absorption to provide good synchronization and availability of carbonate calcium for eggshell calcification in the oviduct (Zhang and Coon, 1997).

In the present study, calcium absorption was favored by the effect of corn particle size on the digestive tract. Rohe et al. (2014) reported that coarser granulometry influences gastrointestinal function and development, as well as the microstructure of the intestinal epithelium. These factors would be closely associated with digestibility. Contrasting results regarding egg quality were described by Safaa et al. (2009) and Witt et al. (2009), who reported that different corn and limestone particle sizes do not influence eggshell quality, respectively.

#### 4. Conclusion

It is suggested that semi-heavy laying hens should be fed mash diets containing corn particles with a GMD from 605 to 1,030  $\mu\text{m}$ , because coarse corn particle causes negative effect on eggshell quality. Thicker eggshells are more desirable because they decrease the chances of breaking during transportation and marketing, preventing economic losses for all links in the poultry production chain.

#### Conflict of interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the content of this paper.

#### References

- Attia YA, El-Tahawy WS, Abd El-Hamid AE, Hassan SS, Nizza A, El-Kelaway MI. Effect of phytase with or without multienzyme supplementation on performance and nutrient digestibility of young broiler chicks fed mash or crumble diets. *Ital J Anim Sci* 2012;11:e56.
- Attia YA, El-Tahawy WS, Abd El-Hamid AE, Nizza A, Bovera F, Al-Harathi MA, et al. Effect of feed form, pellet diameter and enzymes supplementation on growth performance and nutrient digestibility of broiler during days 21–37 of age. *Arch Anim Breed* 2014a;34:1–11.
- Attia YA, El-Tahawy WS, Abd El-Hamid AE, Nizza A, El-Kelway MI, Al-Harathi MA, et al. Effect of feed form, pellet diameter and enzymes supplementation on carcass characteristics, meat quality, blood plasma constituents and stress indicators of broilers. *Arch Anim Breed* 2014b;30:1–14.
- El-Sabroun K. Effect of rearing system and season on behaviour, productive performance and carcass quality of rabbit: a review. *J Anim Behav Biometeorol* 2018;6:102–8.
- Frikha M, Safaa HM, Serrano MP, Arbe X, Mateos GG. Influence of the main cereal and feed form of the diet on performance and digestive tract of brown-egg laying pullets. *Poultry Sci* 2009;88:994–1002.
- Frikha M, Safaa HM, Serrano MP, Jiménez-Moreno E, Lázaro R, Mateos GG. Influence of the main cereal in the diet and particle size of the cereal on productive performance and digestive traits of brown-egg laying pullets. *Anim Feed Sci Technol* 2011;164:106–15.
- Fronte B, Bayram I, Akkaya AB, Rossi G, Bagliacca M. Effect of corn particle size and inclusion of organic acid in the diet on growth performance and gastrointestinal structure in young chicks. *Ital J Anim Sci* 2013;12:567–72.
- Gewehr CE, Oliveira V, Costenaro J, Pagno G, Rosniecek M, Farias DK. Whole and ground corn in different feeding systems for brown laying hens. *Arq Bras Med Vet Zootec* 2011;63:1429–36.
- Gewehr CE, Oliveira V, Miquelluti DJ, Rosniecek M, Farias DK. Whole and ground corn in the food of brown laying hens. *Arch Vet Sci* 2010;15:36–42.
- Hafeez A, Mader A, Ruhnke I, Manner K, Zentek J. Effect of feed grinding methods with and without expansion on prececal and total tract mineral digestibility as well as on interior and exterior egg quality in laying hens. *Poultry Sci* 2016;95:62–9.
- Herreira J, Saldaña B, Guzmán P, Cámara L, Mateos GG. Influence of particle size of the main cereal of the diet on egg production, gastrointestinal tract traits, and body measurements of brown laying hens. *Poultry Sci* 2017;96:440–8.
- Mascarenhas NMH, Costa ANL, Pereira MLL, Caldas ACA, Batista LF, Andrade ELG. Thermal conditioning in the broiler production: challenges and possibilities. *J Anim Behav Biometeorol* 2018;6:52–5.
- Nir I, Hiller G, Shefet G, Nitsan Z. Effect of grain particle size on performance: 2. Grain texture interactions. *Poultry Sci* 1994;6:781–91.
- Rohe I, Ruhnke I, Knorr F, Mader A, Borojenti FG, Lowe R, et al. Effects of grinding method, particle size, and physical form of the diet on gastrointestinal morphology and jejunal glucose transport in laying hens. *Poultry Sci* 2014;93:2060–8.
- Rostagno HS, Albino LFT, Donzele JL, Paulo CG, Rita FO, Lopes DC, et al. Tabelas brasileiras para aves e suínos: composição de alimentos e exigências nutricionais. 3 ed. Viçosa: UFV; 2011.
- Safaa HM, Moreno EJ, Valencia DG, Frikha M, Serrano MP, Mateos GG. Effect of main cereal of the diet and particle size of the cereal on productive performance and egg quality of brown egg laying hens in early phase of production. *Poultry Sci* 2009;88:608–14.
- Stadleman WJ. Quality identification of shell egg. In: Stadleman WJ, Cotterill OJ, editors. *Egg science and technology*. Connecticut: AVI Publishing Company Inc.; 1977. p. 36.
- Witt FH, Kuleile NP, Van Der Merwe HJ, Fair MD. Effect of limestone particle size on egg production and eggshell quality of hens during late production. *S Afr J Anim Sci* 2009;39:37–40.
- Zanotto DL, Bellaver C. Método de determinação da granulometria de ingredientes em rações de suínos e aves. In: EMBRAPA-CNPQA (comunicado técnico 215); 1996. <https://www.embrapa.br/busca-de-publicacoes/-/publicacao/433741/metodo-de-determinacao-da-granulometria-de-ingredientes-para-uso-em-racoes-de-suinos-e-aves>. [Accessed 15 June 2018].
- Zhang B, Coon NC. The relationship of calcium intake, source, size, solubility in vitro and in vivo, and gizzard limestone retention in laying hens. *Poultry Sci* 1997;76:1627–840.